Chapter G4: RUM Analysis

Introduction

Chapter Contents

This case study uses a random utility model (RUM) approach to estimate the effects of improved fishing opportunities due to reduced impingement and entrainment (I&E) in the Great Lakes region. The Great Lakes region includes all facilities in scope of the Phase II rule that withdraw water from Lakes Ontario, Erie, Michigan, Huron, and Superior or are located on a waterway with open fish passage to a Great Lake and within 30 miles of the lake. The case study uses data from the Michigan Department of Natural Resources (MDNR) recreational angler survey (MDNR, 2002) conducted in 2001, which surveyed anglers at fishing sites on Lakes Michigan, Huron, Superior, and Erie. EPA applied benefits estimated for Michigan anglers to anglers in other Great Lakes states.

Cooling Water Intake Structures (CWIS) withdrawing water from the Great Lakes and connecting tributaries impinge and entrain many species sought by recreational anglers, including bass, perch, walleye, salmon, and other species. Accordingly, EPA included the following species groups in the model: bass-perch, walleye-pike, salmon-trout, and general.[1]

The study's main assumption is that, all else being equal, anglers will get greater satisfaction and thus greater economic value from sites with a higher catch rate. This benefit may occur in two ways: first, an angler may get greater enjoyment from a given fishing trip with higher catch rates, yielding a greater value per trip; second, anglers may take more fishing trips when catch rates are higher, resulting in greater overall value for fishing in the region.[2]

The following sections describe the data set used in the analysis and present analytic results. Chapter A11 of this report provides a detailed description of the RUM methodology used in this analysis.

G4-1 Data Summary

EPA's analysis of improvements in recreational fishing opportunities in the Great Lakes region relies on the Michigan Department of Natural Resources study: *Measurement of Sportfishing Harvest in Lakes Michigan, Huron, Erie, and Superior* (MDNR, 2002).[3] The model of recreational fishing behavior relies on a subset of the 2001 MDNR data for boat, shore, and

[1] Bass-perch includes largemouth bass, rock bass, smallmouth bass, white bass, white perch, and yellow perch; walleye-pike includes muskellunge, tiger muskellunge, northern pike, and walleye; salmon-trout includes Atlantic trout, brook trout, brown trout, lake trout, rainbow trout, chinook salmon, coho salmon, pink salmon, siscowet, splake, and other salmon and trout; and the general category includes all of these species, plus all other species (including catfish, crappie, herring, whitefish, and pumpkinseed).

[2] MDNR did not collect the information needed to estimate a participation model. Therefore, the welfare estimates presented in this chapter are based on the baseline level of participation. This approach will underestimate total welfare effects, to the extent that the number of trips would increase with improved fishing quality.

[3] The data required to calculate a RUM model for other Great Lakes states were not available.

ice-fishing anglers, which included 9,256 anglers.[4] Anglers who live outside of Michigan and anglers who travel more than 120 miles one way to the fishing site were excluded.[5] EPA then randomly selected 10,000 anglers from the resulting data set.[6] After additional data cleaning, EPA estimated the RUM model using data for 9,256 anglers.

The Agency included both single- and multiple-day trips in estimating the total economic gain from improvements in fishing site quality from reduced I&E. Details of this analysis are provided in Section G4-3 of this report.

G4-1.1 Summary of Anglers' Characteristics

a. Fishing modes and targeted species

Table G4-1 presents summary statistics on fishing mode and targeted species for the RUM sample of anglers. Almost 66 percent of anglers in the sample fished from boats; 23 percent fished from piers, docks, or shore; and 11 percent fished from open ice or shanty. EPA did not estimate values by mode in the RUM model for two reasons. First, in testing different models, EPA found that values were fairly consistent across modes. Second, data are not available on numbers of trips by mode, so welfare estimation relies only on the total number of trips. Almost 59 percent of anglers target either salmon or trout species; 20.5 percent target bass or perch; 13.5 percent target walleye or pike; and 7.4 percent do not target a particular species.

Table G4-1: Mode Choice and Targeted Species

Fishing Mode	Number of Anglers	Percent of Sample
Boat	6,088	65.77%
Pier/Dock	882	9.53%
Shore	1,231	13.30%
Open Ice	831	8.98%
Shanty	224	2.42%
Targeted Species	**Number of Anglers**	**Percent of Sample**
Bass-Perch	1,895	20.47%
Walleye-Pike	1,249	13.49%
Salmon-Trout	5,427	58.63%
No Target	685	7.40%

Source: MDNR, 2002.

b. Anglers' characteristics

This section presents a summary of angler characteristics, for anglers in the RUM sample. Table G4-2 summarizes this information. On average, anglers in the case study area traveled 30.6 miles, one way, to the visited fishing site. The average round trip travel cost, excluding opportunity cost of time, was $21; and the average travel cost, including opportunity cost of time, was $31.46. The average angler in the Michigan survey fished for 3.8 hours on the intercepted trip. The MDNR study did not collect socio-economic data. Therefore, EPA used median household income data by zip code, from the 2000 U.S. Census, to approximate income data for survey respondents.[7] The average annual census data income for the respondent anglers was $39,151.

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[4] MDNR also surveys charter boat anglers. EPA did not include charter anglers in the model, because the charter data are not exactly comparable to the data from surveys of boat, shore and ice anglers.

[5] The MDNR data did not distinguish between single-day and multiple-day trips. Anglers who traveled more than 120 miles one way were excluded from the model, based on the assumption that these longer trips are most likely multiple-day trips.

[6] EPA decreased the size of the data set to accommodate software and computer resource limitations.

[7] Census data for median income by zip code are from Census Summary File 3 (U.S. Census Bureau, 2002).

Table G4-2: Data Summary for Anglers in the RUM Sample (N=9,256)

Variable	Mean Value	Std Dev	Minimum	Maximum
One Way Distance to Visited Site (Miles)	30.57	30.82	0.40	119.9
Trip Cost[a,c]	$21.09	$21.27	$0.28	$82.73
Travel Cost[a,c]	$31.46	$32.65	$0.43	$155.22
Household Income[c]	$39,151	$8,800	$11,667	$112,809
Average Hours Fished (n=44,933)[d]	3.79	2.46	0	19

[a] Trip cost is the round trip cost to the visited site, excluding opportunity cost of time.
[b] Travel cost is the round trip cost to the visited site, including opportunity cost of time.
[c] Calculation of these values is described in Section G4-1.4, below.
[d] Calculated for entire Michigan sample.

Sources: MDNR, 2002 and U.S. Census Bureau, 2002.

G4-1.2 Recreational Fishing Choice Sets

Figure G1-1 in Chapter G1 shows both the entire Great Lakes region and the geographic area included in the RUM analysis. To analyze welfare effects from I&E in the Great Lakes region, the Agency first modeled recreational anglers' behavior in the state of Michigan. This analysis includes only Great Lakes sites and sites on tributaries up to 30 miles from the lakes in the state of Michigan. EPA did not include other river and lake sites in the model, because catch rate data were not available for these sites, and because the large size of the resulting data set would lead to estimation problems.

MDNR provided data on site locations, catch rates, and other site characteristics, such as fish stocking and presence of boat ramps. Each angler's choice set was drawn from 105 Great Lakes sites in Michigan for which catch rate data were available over a five-year period (1997-2001). EPA initially included all 331 Great Lakes fishing sites in Michigan that were included in the MDNR database, interpolating catch rate values for sites without catch data. Inclusion of the interpolated catch rates did not produce satisfactory model results for no-target anglers. The results for target anglers were similar with and without the interpolated catch rates, so in the model reported here EPA included only sites with measured catch rates.

EPA selected each angler's choice set by, first, eliminating all sites farther than 120 miles from the angler's home zip code,[8] and then randomly selecting up to 74 sites per angler: 37 warm-water species sites and 37 cold-water species sites. Each angler's choice set, by definition, includes the site actually visited. For the final RUM model, EPA did not distinguish between warm-water and cold-water species groups. Therefore, the average number of sites in each angler's choice set for the RUM was 12, and ranged from 6 to 23 sites.[9]

G4-1.3 Site Attributes

This analysis assumes that the angler chooses among site alternatives based on catch rates at each site, and whether fish are stocked at the site. Catch rate is the most important attribute of a fishing site from the anglers' perspective (McConnell and Strand, 1994; Haab et al., 2000). This attribute is also a policy variable of concern because catch rate is a function of fish abundance, which is affected by fish mortality due to I&E. The catch rate variable in the RUM therefore provides the means to measure baseline losses in I&E and changes in anglers' welfare attributed to changes in I&E due to the final section 316(b) rule.

[8] Agency's assumption for single-day anglers based on the 99th percentile for the distance traveled by single-day anglers to a fishing site in other regions.

[9] Originally, following Lupi and Hoehn (1997), EPA attempted to estimate a nested logit model, with separate nests for warm-water species/sites and cold-water species/sites. However, the model results were not as good as those from a single logit model, most likely due to a large overlap in warm- and cold-water species fishing sites.

To specify the fishing quality of the case study sites, EPA calculated historic catch rate based on MDNR creel surveys for the years 1997 to 2007 for recreationally important species: bass and perch, walleye and pike, salmon and trout, and a "general" catch rate, which includes these species plus all other species. The catch rates represent the number of fish caught on a fishing trip divided by the number of hours spent fishing (i.e., the number of fish caught per hour per angler). The estimated catch rates are averages across all anglers in a given year over the five-year period.

The catch rate variables include total catch, including fish caught and kept and fish released. Some studies use the catch-and-keep measure as the relevant catch rate. Although a greater error may be associated with measured number of fish not kept, the total catch measure is most appropriate because a large number of anglers catch and release fish. For anglers who don't target any species, EPA used the "general" catch rate to characterize fishing quality.

Table G4-3 summarizes average catch rates by species for all sites with data in the study area. Anglers who target bass or perch catch the most fish per hour, followed by anglers who target walleye or pike, and anglers who target salmon or trout.

Table G4-3: Average Catch Rates (1997-2001) for MI Great Lakes Sites with Measured Catch Rates (N=105) (number of fish per hour)

Species	Mean Value	Std Dev	Minimum	Maximum
Bass-Perch	0.8166	1.35	0	7.95
Walleye-Pike	0.2157	0.36	0	2.15
Salmon-Trout	0.126	0.11	0	0.67
General	0.2861	0.28	0	1.54

Source: MDNR, 2002.

In addition to catch rates, anglers may view boat launching facilities and fish stocking at a site as important factors that may affect their site choice. EPA therefore included dummy variables in the model to indicate whether a site had boat launch facilities, and whether stocking occurs at each site. The boat launch dummy was not statistically significant, so only the stocking dummy was including in the final model. Each stocking site was linked to the closest survey site within 1 kilometer. Of the 105 sites with measured catch rates, 56 (53.3 percent) had stocking sites within 1 kilometer.

G4-1.4 Travel Cost

EPA used ArcView 3.2a software to estimate distances from each angler's zip code to each fishing site. The Agency obtained fishing site locations from a database supplied by the MDNR. The distance estimation program measured the distance in miles for the shortest route, using state and U.S. highways, from the household zip code to each fishing site, then added the distances from the zip code location to the closest highway and from the site location to the closest highway. The average one way distance to the visited site for all modes is 30.6 miles.

EPA estimated trip "price" as the sum of travel costs plus the opportunity cost of time following the procedure described in Haab et al. (2000). Based on Parsons and Kealy (1992), this study assumed that time spent "on-site" is constant across sites and can be ignored in the price calculation. To estimate anglers' travel costs, EPA multiplied round trip distance by average motor vehicle cost per mile ($0.345, 2001 dollars).[10] To estimate the opportunity cost of travel time, EPA first divided round trip distance by 40 miles per hour to estimate trip time, and next used one third of the household's wage to yield the opportunity cost of time. EPA estimated household wage by dividing household income by 2,080 (i.e., the number of full time hours potentially worked).

[10] EPA used the 2001 government rate ($0.345) for travel reimbursement to estimate travel costs per mile traveled. This estimate includes vehicle operating cost only.

EPA calculated visit price as:

$$Visit\ Price = (Round\ Trip\ Distance \times \$.345) + \left[\frac{Round\ Trip\ Distance}{40\ mph} \times (Wage) \times 0.33 \right] \qquad \text{(G4-1)}$$

G4-2 SITE CHOICE MODELS

EPA used a RUM model, as described in Chapter A11 of this report, to estimate anglers' site choices. The model assumes that the individual angler makes a choice among mutually exclusive site alternatives based on the attributes of those alternatives. EPA identified each angler's choice set based on a travel distance constraint. All fishing sites within a 120 mile distance from the angler's hometown are eligible for inclusion in the angler's choice set. To prevent the model from becoming overly complex, EPA estimated the site choice model using the site actually visited and up to 22 randomly drawn sites from the choice set for each angler.

An angler's choice of sites relies on utility maximization. An angler will choose site *j* if the utility (u_j) from visiting site *j* is greater than that from vising other sites (*h*), such that:

$$u_j > u_h \qquad for\ h = 1, \ldots J\ and\ h \neq j \qquad \text{(G4-2)}$$

Recreational fishing models generally assume that anglers first choose a fishing mode (i.e., boat or shore) and species (e.g., warm water or cold water), and then a site. Instead of incorporating the angler's decision regarding the mode of fishing and target species in the model, the Agency assumed that the mode/species choice is exogenous to the model and the angler simply chooses the site. EPA used the following general model to specify the deterministic part of the utility function:

$$v_j = f\,(TC_j\ STOCK_j,\ TARGET_s * \sqrt{CATCH_{sj}}) \qquad \text{(G4-3)}$$

where:

v_j	=	the expected utility for site *j* (*j*=1,...105);
TC_j	=	travel cost to site *j*;
$STOCK_j$	=	fish stocking at site *j*;
$TARGET_s$	=	dummy variable indicating whether species *s* is targeted or not; and
$CATCH_{sj}$	=	catch rate for species s at site *j*.

Table G4-4 gives the parameter estimates for this model.

Table G4-4: Estimated Coefficients for the Conditional Site Choice Model

Variable	Estimated Coefficient	t-statistic
TRAVEL COST	-0.0501	-84.24
SQRT(BASS-PERCH)	1.4185	33.23
SQRT(WALLEYE-PIKE)	3.0271	23.70
SQRT(SALMON-TROUT)	3.1975	25.46
SQRT(GENERAL)	0.9351	5.59
STOCK	0.5121	19.28

Source: U.S. EPA analysis for this report.

Table G4-4 shows that all coefficients have the expected signs and are statistically significant at the 99th percentile. Travel cost has a negative effect on the probability of selecting a site, indicating that anglers prefer to visit sites closer to their homes (other things being equal). A positive sign on the stock variable indicates that anglers are more likely to choose sites where fish are stocked.

EPA estimated a number of model specifications, including models that allowed values to vary by fishing mode, and a nested model that distinguished between cold- and warm-water species. The Agency found the model presented here provided the best fit for the data.

G4-3 Welfare Estimates

This section presents estimates of welfare losses to recreational anglers from fish mortality due to I&E, and potential welfare gains from improvements in fishing opportunities due to reduced fish mortality stemming from the final section 316(b) rule.

G4-3.1 Estimating Changes in the Quality of Fishing Sites

To estimate changes in the quality of fishing sites under different policy scenarios, EPA used estimates of recreational losses from I&E, combined with recreational fishery landings data by state. I&E affects recreational species in two ways: by directly killing recreational species, and by killing forage species, thus indirectly affecting recreational species through the food chain. The indirect effects on recreational species were calculated in two steps. First, EPA estimated the total number of fish lost due to forage fish losses. Second, EPA allocated this total number of fish among recreational species according to each species' percent of total recreational landings.

EPA obtained recreational landings data from each state in the Great Lakes region: New York, Pennsylvania, Ohio, Michigan, Illinois, Indiana, Wisconsin, and Minnesota. Some states reported both the number of fish harvested and the total number of fish caught, which includes fish caught and released. EPA used the total number of fish caught to measure total landings. For states that only reported fish harvested, EPA adjusted harvest figures upward, using adjustment factors based on the average proportion of catch to harvest in Indiana, Pennsylvania, and Michigan, the three states that reported both values. The adjustment factors ranged from 1.09 for walleye to 9.28 for bass.

The Agency estimated changes in the quality of recreational fishing sites under different policy scenarios in terms of the percentage change in the historic catch rate. The Agency assumed that catch rates will change uniformly across all fishing sites in the region where each species is found.[11,12] For each species included in the model, EPA used five-year recreational landings data (1997-2001) to calculate average landings per year. EPA then divided losses to the recreational fishery from I&E by the total recreational landings for the region to calculate the percent change in historic catch rate from eliminating I&E completely. Table G4-5 presents results of this analysis. Table G4-6 presents estimated improvements in catch rates, over baseline losses, for the preferred technology option at each facility. The preferred technology is estimated to reduce impingement by 51.5 percent, and entrainment by 40.1 percent.

[11] This assumption may not hold across lakes, as some lakes (e.g., Lakes Michigan and Erie) have more facilities, and therefore are likely to have greater benefits from reduced I&E. However, data were not sufficient to estimate welfare changes by lake.

[12] Fish lost to I&E are most often very small fish, which are too small to catch. Because of the migratory nature of most affected species, by the time these fish have grown to catchable size, they may have traveled some distance from the facility where I&E occurs. Without collecting extensive data on migratory patterns of all affected fish, it is not possible to evaluate whether catch rates will change uniformly or in some other pattern. Thus, EPA assumed that catch rates will change uniformly across each lake.

Table G4-5: Estimated Changes in Catch Rates from Eliminating all I&E of Affected Species in the Great Lakes Region

Species	Total Recreational Losses from I&E (number of fish)	Total Recreational Landings (fish per year)	Percent Increase in Recreational Catch from Elimination of I&E
Bass-Perch	1,466,453	13,856,741	10.58%
Walleye-Pike	94,289	1,693,872	5.57%
Salmon-Trout	120,661	1,905,185	6.33%
No Target/General[a]	3,061,981	28,885,829	6.61%

[a] Total landings for the no target/general category include all fish reported in catch or harvest data by each state. Total recreational losses for this category are the sum of losses over all species.

Sources: MDNR, 2002; U.S. EPA analysis for this report.

Table G4-6: Estimated Changes in Catch Rates from Reducing I&E of Affected Species in the Great Lakes Region under the Preferred Technology Option

Species	Total Recreational Losses from I&E (number of fish)	Total Recreational Landings (fish per year)[a]	Percent Increase in Recreational Catch from Reduction of I&E
Bass-Perch	692,338	13,856,741	5.0%
Walleye-Pike	46,874	1,693,872	2.77%
Salmon-Trout	60,360	1,905,185	3.22%
No Target/General[a]	1,484,324	28,885,829	3.20%

[a] Total landings for the no target/general category include all fish reported in catch or harvest data by each state. Total recreational losses for this category are the sum of losses over all species.

Sources: MDNR, 2002; U.S. EPA analysis for this report.

G4-3.2 Estimating Losses from I&E in the Great Lakes

The recreational behavior model described in the preceding sections provides a means for estimating the economic effects of recreational fishery losses from I&E in the Great Lakes region. First, EPA estimated welfare gain to recreational anglers from eliminating fishery losses due to I&E. This estimate represents economic damages to recreational anglers from I&E of recreational fish species in the Great Lakes region under the baseline scenario. EPA then estimated benefits to recreational anglers from implementing the preferred CWIS technologies.

EPA estimated anglers' willingness-to-pay (WTP) for improvements in the quality of recreational fishing by first calculating an average per-day welfare gain based on the expected changes in catch rates from eliminating I&E. Table G4-7 presents the compensating variation per trip (averaged over all anglers in the sample) associated with reduced fish mortality from eliminating I&E for each fish species group of concern, and the per-trip welfare gain attributable to reduced I&E resulting from the preferred technology option.[13] Table G4-7 also shows the per-trip welfare gain for a one fish increase in catch rates.

[13] A compensating variation equates the expected value of realized utility under the baseline and post-compliance conditions. For more detail, see Chapter A11 of this report.

Table G4-7: Per-Trip Welfare Gain from Eliminating I&E and I&E Reductions with the Preferred Technology in the Great Lakes Region

Targeted Species Group	Per-Trip Welfare Gain (2002$)		WTP for an Additional Fish per Trip (2002$)
	Eliminating I&E	Reduced I&E with Preferred Technology	
Bass-Perch	$2.37	$1.13	$3.11
Walleye-Pike	$1.18	$0.59	$11.55
Salmon-Trout	$0.81	$0.42	$15.11
General - No Target	$0.33	$0.16	$3.60

Source: U.S. EPA analysis for this report.

Table G4-7 shows that anglers targeting bass or perch have the largest per-trip gain ($2.37) from eliminating I&E; followed by anglers targeting walleye or pike ($1.18), anglers targeting salmon or trout ($0.81), and no-target anglers ($0.33). Table G4-7 also reports the WTP for a one-unit increase in historic catch rate by species. For anglers who target a particular species, salmon and trout are the most highly valued fish, followed by walleye and pike, and bass and perch. The values for a one fish increase in catch are consistent with values estimated in other studies (Whitehead and Aiken, 2000; Lupi and Hoehn, 1997).

EPA calculated the total economic value of eliminating I&E in the Great Lakes region by multiplying the estimated per-trip welfare gain by the total number of fishing days in the region. The Great Lakes data did not indicate whether a trip was a single- or multiple-day trip. EPA assumes that by limiting travel distance in selecting angler's choice sets, the Agency has eliminated most multiple-day trips from the data. Therefore, EPA assumes that per-trip values as estimated in the model are equivalent to per-day values.

EPA obtained data on the total number of fishing days from the U.S. Fish and Wildlife Services' (FWS) annual survey of fishing, hunting, and wildlife-related recreation (U.S. Fish and Wildlife Service, 2001). This total number of fishing days includes both single- and multiple-day trips. Table G4-8 presents the number of fishing days by species. The number of days presented for each species in the table were adjusted downward from the FWS totals to avoid double counting of days per species.[14]

Table G4-8: Recreational Fishing Participation in 2001, by Species, for the Great Lakes Region

Species	Total Number of Fishing Days per Year
Bass-Perch	8,038,933
Walleye-Pike	4,295,665
Salmon-Trout	8,467,817
No Target	1,237,618
All Other Species	1,097,967

Source: U.S. Fish and Wildlife Service, 2001.

[14] Some anglers surveyed by FWS reported targeting more than one species. Therefore, EPA adjusted the total number of days per species to add up to the total number of reported fishing days for all species. EPA multiplied the total reported days for each species by that species' portion of total days for all species.

The Agency assumed that the welfare gain per day of fishing is independent of the number of days fished per trip and therefore equivalent for both single- and multiple-day trips.[15] Each day of a multiple-day trip is valued the same as a single-day trip. In the Great Lakes region, anglers who target salmon or trout fish the most days, followed by anglers who target bass or perch, anglers who target walleye or pike, anglers targeting any species (i.e., no-target anglers), and anglers who target all other species. When estimating total welfare, EPA used the no-target per-day welfare estimates to estimate welfare changes for anglers who target all other species.[16]

The estimated number of trips represents the baseline level of participation. Anglers may take more fishing trips as recreational fishing circumstances change. However, EPA was unable to estimate a trip participation model for the Great Lakes, because the required data were not available. Therefore, the welfare estimates presented here do not account for likely increases in the number of trips due to elimination of I&E, and thus understate total welfare effects.

Tables G4-9 and G4-10 provide total annual welfare estimates for two policy scenarios. These values were discounted, to reflect the fact that fish must grow to a certain size before they will be caught by recreational anglers. EPA calculated discount factors separately for I&E of each species. To estimate discounted total benefits, EPA calculated weighted averages of these discount factors for each species group, and applied them to estimated WTP values. Discount factors were calculated for both a 3 percent discount rate and a 7 percent discount rate. For the preferred technology option, an additional discount factor was applied to account for the 1-year lag between the date when installation costs are incurred and the installation of the required cooling water technology is completed.

Table G4-9 presents annual losses to recreational anglers from baseline I&E effects in the Great Lakes region. Total recreational losses (2002$) to Great Lakes anglers, before discounting, from I&E of bass, perch, walleye, pike, and other species are $31.7 million per year. Total discounted baseline losses are $29.4 million, discounted using a 3 percent discount rate; and $26.7 million, discounted using a 7 percent discount rate.

Table G4-10 presents the annual welfare gain to recreational anglers resulting from installation of the preferred CWIS technology at Great Lakes facilities. Total undiscounted gain to recreational anglers is $15.5 million under the preferred technology option. Total discounted gain is $13.9 million, discounted using a 3 percent discount rate; and $12.2 million, discounted using a 7 percent discount rate.

Table G4-9: Total Estimated Annual Baseline Losses from I&E for Great Lakes Anglers (2002$)

Species	Total Losses Before Discounting	Total Losses with 3% Discounting	Total Losses with 7% Discounting
Bass-Perch	$19,053,075	$17,597,267	$15,937,097
Walleye-Pike	$5,064,160	$4,639,135	$4,167,403
Salmon-Trout	$6,887,722	$6,456,509	$5,973,391
No Target (Anything)	$406,310	$374,458	$338,613
Other Targets	$360,463	$331,084	$298,419
Total Recreational Use Losses	$31,771,730	$29,398,453	$26,714,923

Source: U.S. EPA analysis for this report.

[15] See section G4-4.2 for limitations and uncertainties associated with ths assumption.

[16] Other species that are affected by I&E include crappie, sunfish, catfish, whitefish, rainbow smelt, and bluegill.

Table G4-10: Total Estimated Annual Welfare Gain to Great Lakes Anglers Under the Preferred Technology Option (2002$)

Species	Total Before Discounting	Total with 3% Discounting	Total with 7% Discounting
Bass-Perch	$9,083,190	$8,151,197	$7,114,519
Walleye-Pike	$2,530,147	$2,251,517	$1,948,356
Salmon-Trout	$3,525,999	$3,209,732	$2,859,389
No Target (Anything)	$198,390	$177,587	$154,691
Other Targets	$176,004	$156,970	$136,231
Total Recreational Use Losses	$15,513,730	$13,947,003	$12,213,186

Source: U.S. EPA analysis for this report.

G4-4 Limitations and Uncertainties

G4-4.1 Considering Only Recreational Values

This study understates the total benefits of improvements in fishing site quality because estimates are limited to recreation benefits. Many other forms of benefits, such as habitat values for a variety of species (in addition to recreational fish), non-use values, etc., are also likely to be important.

G4-4.2 Modeling

a. Multiple-day trips

The Michigan survey data did not distinguish between single-day and multiple-day trips. EPA deleted all trips with one way travel distance greater than 120 miles, assuming that most of these trips would be multiple-day trips. It is possible that anglers who take multiple-day trips have different values for fishing site quality than anglers who take single-day trips. EPA estimated total welfare using data provided by the FWS on total number of fishing days in the Great Lakes, including both single-day and multiple-day trips. It is not clear how these issues will affect total welfare.

b. Substitute sites

Due to data and software limitations, inland sites (i.e., fishing sites not located on the Great Lakes or their tributaries) were not included in the RUM model. Thus, the model did not include the full range of substitute sites for each angler. However, it is likely that other inland sites do not provide close substitutes to Great Lakes fishing sites. In addition, the RUM model included a large number of sites for each angler.

G4-4.3 Data

a. Estimates of total recreational landings

EPA did not have total catch (i.e., catch and release plus catch and keep) data for all Great Lakes states. Five of the eight Great Lakes states only provided data on harvest (i.e., catch and keep). Therefore, EPA adjusted harvest estimates to total catch estimates based on the percent difference between harvest and catch and release for the three states that reported both. For yellow perch, walleye, and salmon-trout, the adjustment factors were similar across the three states for which data were available. For bass, the adjustment factor ranged from 2.6 to 15.8, with an average of 9.3. Therefore, it is likely that the bass adjustment factor differs across the other five states. It is not possible to determine whether, on average, these variations would result in higher or lower estimated changes in catch rates.

b. Survey sampling effects

Recreational demand studies frequently face observations that do not fit general recreation patterns, such as observations of avid participants. These observations tend to be overly influential even when the reports are correct (Thomson, 1991).

G4-4.4 Assumption of Uniform Change in Catch Rates Across All Lakes

Each of the Great Lakes has a different number of power plants, and therefore will have different levels of losses caused by I&E. For this study, EPA averaged I&E losses over all lakes, and assumed that catch rates would change uniformly across lakes with elimination or reduction of I&E. While this is not a completely realistic assumption, the data were not sufficient to estimate separate welfare changes for each lake. Therefore, the total welfare could be either overstated or understated.

G4-4.5 Extrapolation of Michigan Values to Other Great Lakes States

EPA estimated recreational fishing values for the Great Lakes using data for the state of Michigan only. The benefit estimates from Michigan were applied to all other states in the Great Lakes region. This may result in either overstatement or understatement of total benefits for the Great Lakes, depending on how recreational fishing values vary across states. Recreational fishing values depend on availability of substitute sites and presence and abundance of recreational species, among other things.